Effect of Ambe Bahar fruiting periodicity on sex expression, fruit set and fruit quality of pomegranate (*Punica granatum* L) cv Mridula

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ABSTRACT

This study investigated the periodic flowering behaviour of pomegranate cv Mridula during the Ambe Bahar season (March-May) in Hisar, Haryana, over two years (2017-2019). The experiment, conducted on nine-year-old plants, was laid out in a randomized block design with seven uniform plants. Observations included periodic sex expression (male, intermediate, hermaphrodite flowers), sex ratio, pollen viability, fruit set, fruit cracking percentage, fruit weight and juice content. Flowering extended from March to May, with the highest total flower production occurring in April. Male flowers were generally most numerous, followed by hermaphrodite and intermediate flowers. The proportion of male flowers increased, while that of hermaphrodite and intermediate flowers decreased, from March to May. The sex ratio (hermaphrodite to male flowers) gradually decreased from March (1.03 and 1.13) to May (0.36 and 0.32). Pollen viability of hermaphrodite flowers also showed a decreasing trend from March to May, ranging between 82.50 and 91.00 per cent. Fruit set was maximum in April (98.54 and 97.84% in 2017-18 and 2018-19 respectively). Fruit weight and juice content were not significantly influenced by the flowering period. However, fruit cracking was significantly affected. Fruits developed from March flowering exhibited the highest cracking (44.20 and 38.54%), which was considerably higher than fruits from April (28.62 and 26.98%) and May (25.23% and 25.00%) flowering periods in 2017-18 and 2018-19 respectively. These findings emphasize the importance of understanding periodic flowering behavior to optimize fruit management strategies, particularly for thinning and fruit retention, to mitigate cracking and enhance fruit quality in the Ambe Bahar crop in southwestern Haryana.

Keywords: Pomegranate; Ambe Bahar; sex expression; fruit set; fruit quality; fruit cracking

INTRODUCTION

India holds the title of the world's largest pomegranate producer, with Iran following closely behind. Additionally, several other countries including Turkey, Spain, Tunisia, Morocco, Afghanistan, China, Greece, Japan, France, Armenia, Cyprus, Egypt, Italy and Palestine also cultivate this fruit (Anon 2011). In 2021-22, India had an area of 2.7 lakh hectares under pomegranate cultivation with a production of 30.86 lakh metric tonnes and a productivity of 11.4 metric tonnes per ha (Anon 2022). In India, the total production of pomegranates is concentrated mainly in Maharashtra, followed by Gujarat, Karnataka, Andhra Pradesh, Rajasthan and Madhya Pradesh (Madhumathi et al 2023). In Haryana, pomegranate is being grown in very limited area (146.5 ha) with an annual production of 822.7 MT (Anon 2024).

Pomegranate has xerophytic characteristics and hardy nature which is suitable for dry, rainfed, pasture and undulating lands where other fruit crops are not much successful. The yield and quality of pomegranate fruits depend upon the flower regulation which includes selection of flowering flush, leaf shedding intensity after the rest period, pruning method and intensity, application of fertilizers and use of micronutrients, water management and control of

diseases and pests. Under north Indian states, flowering in pomegranate takes place once in a year ie March-May, while sometimes sparse flowering in August and November-December is also observed.

The pomegranate yield is hampered due to problems like fruit cracking and sunburn as a result of temperature variation and irregular soil moisture. In the said region, temperature goes up to 47°C with hot air and drought during May and June which aggravate the problem of fruit cracking and sunburn. Flowering phase in pomegranate is very long which is about 2 months and there is very profuse flowering; only 25 per cent flowers are hermaphrodite and rest are male and intermediate flowers. During flowering and initial fruit growth starts, most of the reserve food material is utilized and gets depleted in flowering and growth of the fruits is adversely affected. Awareness of the control of blossoming time and the possibility of modulating it has considerable potential in fruit trees to increase their productivity as well as to expand their geographic range (Miguel et al 2010). Selection of pomegranate cultivars for the region is also based on habitat, the crop pattern, blossoming physiology and fruiting shift. So, the better understanding of flower patterned biology is required for any crop enhancement plan (Babu et al 2009).

Thinning of the flowers and fruits is a common practice in pomegranate to retain only 70-90 per cent fruits for harvesting. This practice should be followed without any delay to avoid the depletion of sink. Before thinning of flowers and fruits, it is most important to understand the periodicity of sex expression, fruit set and fruit quality even in one Bahar. Fruits born in Ambe Bahar (March-May), within so much long phase of flowering, fruit growth and development experience different environments at different growth stages which result into not only fruits of variable sizes and quality but fruit cracking and sunburn problem also vary with initial to last fruit setting. Keeping in view the above facts, it is imperative to study the periodic flowering behaviour in pomegranate to understand the time of thinning and retaining of fruits so as to harvest good quality fruits with reduced cracking in Ambe Bahar under southwestern zone of Haryana.

MATERIAL and METHODS

The experiment was conducted on nine-year-old plants of the pomegranate cv Maridula in experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar, Haryana during 2017-18 and 2018-2019. Experiment was laid out in randomized block design by selecting seven plants having uniform vigour. The orchard was maintained under uniform cultural practices as per the package of practices for fruit crops, CCS Haryana Agricultural University, Hisar, Haryana. The Ambe Bahar flowering duration was divided into three treatments or periods namely March, April and May. Plant selection was done before flowering for the collection of observations about periodic sex expression viz male flowers, intermediate flowers, hermaphrodite flowers, pollen viability, sex ratio and fruit set. The sex expression in terms of male flowers, intermediate flowers and hermaphrodite flowers was determined by counting the total number of flowers. Hermaphrodite, male and intermediate flowers appeared periodically during March, April and May; their percentages were then calculated for both individual months and the entire period (Plate 1).

Similarly, sex ratio was determined by ratio of hermaphrodite flowers to male flowers periodically in each replication and averaged. Just after fruit set, fruitlets were tagged regularly from the start to end of flowering and marked separately for each period (March, April and May) for each replication. Fruit set was recorded by counting the fruitlets after petal fall on the basis of hermaphrodite flowers for their respective periods.

The viability of pollen grains of hermaphrodite flowers was determined using acetocarmine stain at 1.0 per cent concentration. The fully developed flowers were tapped and the pollen grains were collected in a Petri dish. A camel hair brush was used to transfer the pollen grains from the Petri dish to the surface of a pre-cleaned sterile glass slide. A drop of acetocarmine stain was placed on the centre of the slide where the pollen grains were spread. These pollen grains were covered with a cover slip and number of spores were viewed through an eye piece of microscope. The stained (reddish in colour) and unstained spores were counted in the microscopic field (Plate 2).

The observations were taken under 10 different microscopic fields and the mean viability was worked out. The number of cracked fruits, developed from their respective period of flowering, were counted and fruit cracking percentage was worked out with their respective period of flowering and averaged. Similarly, five representative fruits from each replication and each period were selected and used for estimation of the weight and juice content. Fruit

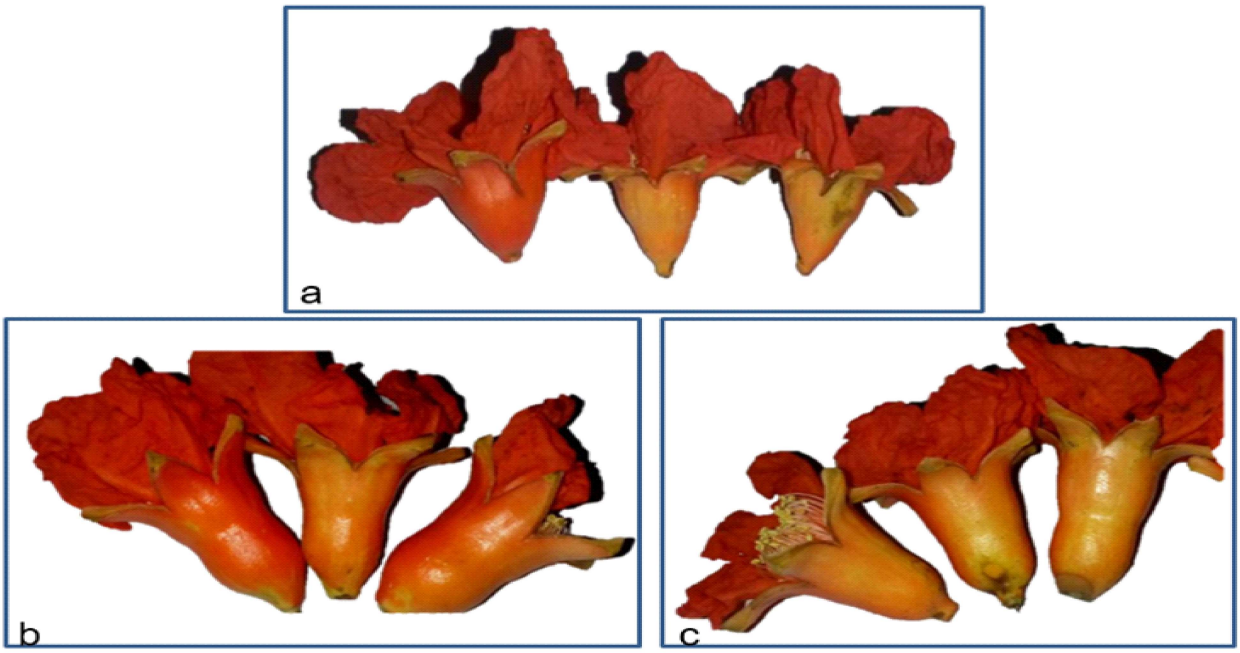

Plate 1. Pomegranate flowers during Ambe Bahar crop, a) Male flowers, b) Bisexual flowers, c) Intermediate flowers

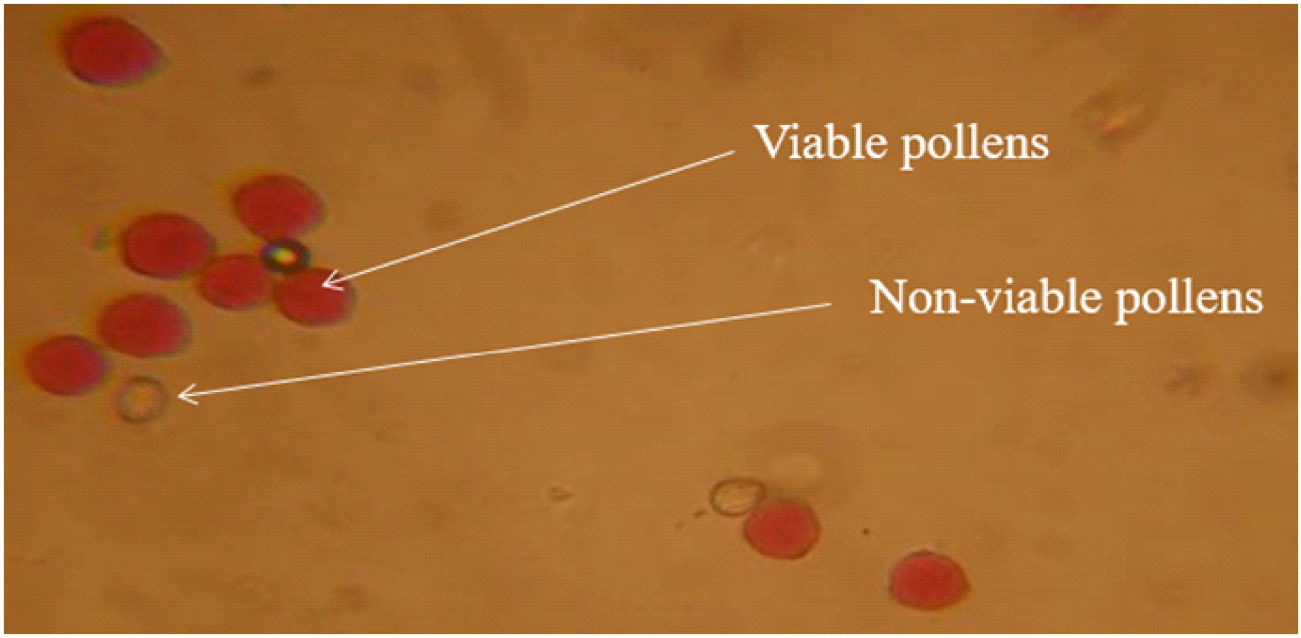

Plate 2. The stained (reddish in colour) and unstained spores under microscopic field

weight was calculated by weighing on electronic balance and juice content was estimated on fruit weight basis.

The data were examined in accordance with the steps outlined by Panse and Sukhatme (1984). Using critical differences (CD) at 5 per cent level of significance, the overall significance of differences between the treatments was examined. A windows-based computer programme called OPSTAT was used to statistically assess the results (Sheoran et al 1998).

RESULTS and DISCUSSION

The observations on periodic sex expression of Ambe Bahar in pomegranate cv Mridula revealed that flowering started during the month of March and continued up to May in both the years of study. Total flowers were 152, 556 and 81 in 2017-18 and 180, 518

Table 1. Effect of Ambe Bahar flowering periodicity on number of flowers and sex ratio in pomegranate cv Mridula

Periodicity	Total number of flowers		Sex ratio (hermaphrodite to male flowers)	
	2017-18	2018-19	2017-18	2018-19
March	152	180	1.03	1.13
April	556	518	0.44	0.44
May	81	89	0.36	0.32
Total	789	787	0.51	0.53

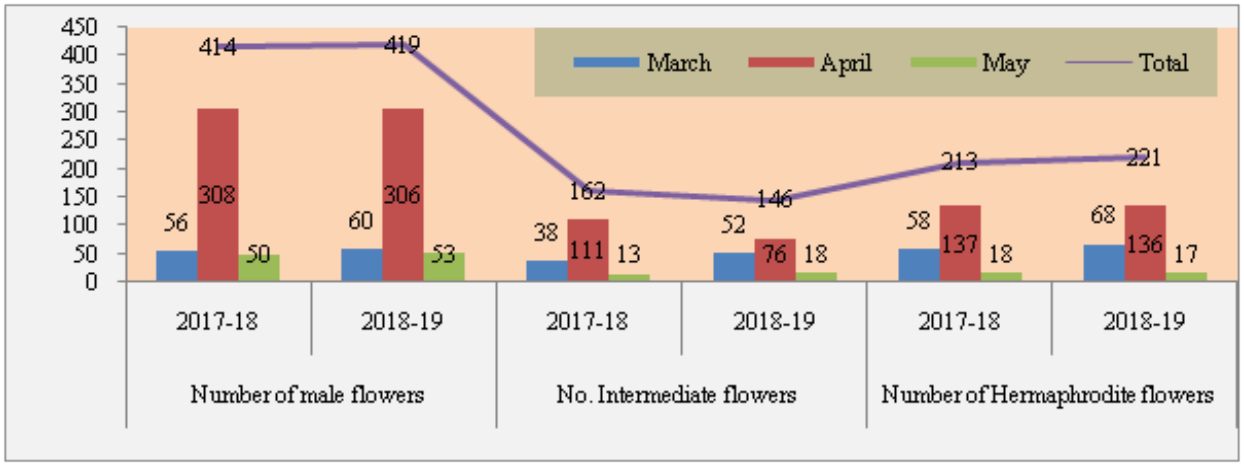

Fig 1. Effect of Ambe Bahar flowering periodicity on sex expression in pomegranate cv Mridula

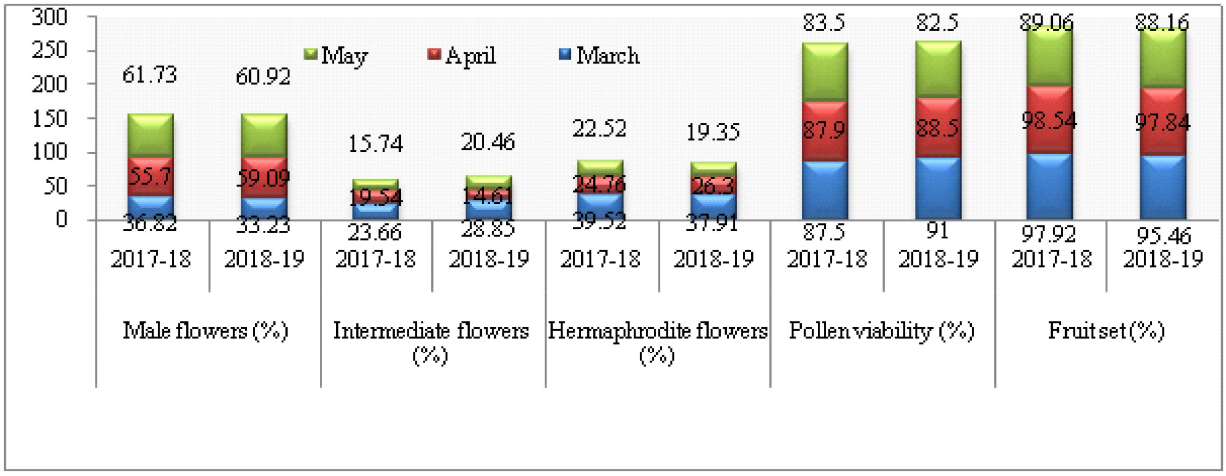

Fig 2. Effect of Ambe Bahar flowering periodicity on sex expression, pollen viability and fruit set of pomegranate cv Mridula

and 89 in 2018-19 during March April and May respectively. Male flowers were observed maximum (414 and 419) followed by hermaphrodite flowers (213 and 221) and intermediate flowers (162 and 146) during 2017-18 and 2018-19 respectively as evident from Table 1 (Fig 1).

The highest number of male (308 and 306), intermediate (111 and 76) and hermaphrodite (137 and 136) flowers was counted in the month of April followed by March and May during both the years respectively. Out of the total flowers produced, the proportion of male, intermediate and hermaphrodite

flowers was observed 52.47 and 53.54 per cent, 20.53 and 18.55 per cent and 27.00 and 28.08 per cent during 2017-18 and 2018-19 respectively (Fig 2). The intensity of the male flowers increased, whereas, that of May (22.52 and 19.35%) during two years respectively (Fig 2). Almost similar trend was observed in case of intermediate flowers. The highest number of intermediate flowers (23.66 and 28.85%) was reported in March followed by April (19.54 and 14.61%) while lowest number of intermediate flowers was found in May (15.74 and 20.46%) during 2017-18 and 2018-19 respectively. However, reverse trend was observed in case of male flowers and highest number was reported in the month of May (61.73 and 60.92%) followed by April (55.70 and 59.09%) and March (36.82 and 33.23%) in two years respectively.

The variation in sex expression during the periodicity of any Bahar might be due to long flowering period and plant has to experience variable environment as the temperature is somewhat mild to severe hot in the region during March to May. The gender proportion changes according to season and sex appearance in pomegranate can differ with period and time of bloom (Kumar et al 2020). Similar results were observed by Marthe et al (2006), who also reported 25-60 per cent hermaphrodite, 20-47 per cent male and 14-24 per cent intermediate flowers in different cultivars of pomegranate.

Earlier, similar observations were made by Singh et al (1978) and Nath and Randhawa (1959). The relationship between male and hermaphrodite flowers determined by environmental factors, periodically changes the age of the plant in pomegranate (Wetzstein et al 2011). There was a gradual decrease in the hermaphrodite to male flower ratio from start to the end of flowering. The highest sex ratio (1.03 and 1.13) was found in March bearing flowers followed by (0.41 and 0.44) in April and minimum (0.36 and 0.32) in May bearing flowers during 2017-18 and 2018-19 respectively (Table 1). The proportion of male to bisexual flowers in pomegranate varied among cultivars and from year to year (Martínez et al 2000). Earlier, Brar (2016) reported variation in bisexual to male flower sex ratio among pomegranate cultivars and observed 0.71 sex ratio in the cultivar Mridula. Similarly, pollen viability of hermaphrodite flowers also decreased from start of flowering to successive months and ranged between (87.50-83.50%) and (82.50-91.00%) during both the years under study (Fig 2). Babu et al (2011) stated that pollen feasibility with acetocarmine stain ranged from 85 to 94 per cent in Ganesh pomegranate. These results are in accordance with the findings of Brar (2016) who reported 92 per cent pollen viability in pomegranate cv Mridula. Prakash et al (2010) reported the highest pollen germination rate at the start of the flowering period, which subsequently decreased in successive flowering periods. Fruit set also varied among various months and ranged from 89.06 to 97 92 per cent and 88.16 to 95.46 per cent during 2017-18 and 2018-2019 respectively (Fig 2). However, the maximum fruit set 98.54 and 97.84 per cent was observed in the month of April bearing flowers during 2017-18 and 2018-2019 respectively. This may be due to high sex ratio and earlier bearing flowers.

Fruit weight and juice content were not affected significantly by the flowering period (Table 2). Fruit weight varied between 154.08 and 143.10 g

Table 2. Effect of Ambe Bahar flowering periodicity on fruit quality of pomegranate cv Mridula

Flowering time	Parameter					
	Average fruit weight (g)		Fruit cracking (%)		Juice content (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
March	154.18	161.56	44.20	38.54	43.13	43.82
April	146.20	150.21	28.62	26.98	42.32	42.79
May	143.10	143.14	25.23	25.00	41.70	43.65
$CD_{0.05}$	NS	NS	12.54	4.90	NS	NS
CV (%)	8.54	9.12	15.68	14.35	5.28	4.50

NS = Non-significant

in 2017-18 and 161.56 and 143.14 g 2018-19 from March to May. Similarly, juice content varied from 43.13 to 41.70 per cent in 2017-18 and 43.82 to 43.65 per cent in 2018-19.

The fruit cracking was significantly influenced by the periodicity of flowering. Fruits developed from March flowering showed maximum cracking 44.20 and 38.54 per cent as compared to fruits developed from April (28.62 and 26.98%) and May (25.23 and 25.00%) during 2017-18 and 2018-2019 respectively, the latter two treatments being at par.

Fruits that developed earlier were more susceptible to cracking than those from later flowering periods. This is likely because earlier fruits had either finished or were completing their cell division stage and were entering the cell expansion phase as the rainy season began. The resulting mild climate, combined with fluctuating moisture, likely caused the expanding arils (fleshy fruit parts) to be less tolerant of these moisture changes, leading to cracking. In contrast, fruits from successive flowering periods were still in the cell division stage or transitioning to cell expansion, making them more resilient to shifts in soil moisture and air humidity and thus less prone to cracking.

Different pomegranate cracking patterns across various seasons were also observed by Sonawane et al (1994). Pant (1976) recorded 63 per cent fruit cracking in spring crop (January-June), 34 per cent in winter crop (October-March) and only 9.5 per cent in rainy season crop (July-December).

Overall, maximum hermaphrodite flowers were observed in March (early flowering period) but in successive flowering duration, hermaphrodite flowers decreased and male flowers increased. This resulted in gradual decrease in sex ratio with successive flowering duration without significant reduction in fruit weight and juice content in Ambe Bahar under southwestern zone of Haryana. However, gradual decrease in fruit cracking was observed with successive flowering from March to May.

Therefore, farmers are advised to strategically manage the flowering time of Ambe Bahar crop of pomegranate, considering key factors such as fruit size, cracking and overall productivity.

CONCLUSION

This study meticulously examined the periodic flowering behaviour of pomegranate cv Mridula during the Ambe Bahar season, yielding critical insights for orchard management in southwestern Haryana. It was observed that while flowering extended from March to May, the proportion of hermaphrodite flowers, crucial for fruit set, decreased progressively from earlier to later flowering periods. This decline was accompanied by a corresponding increase in male flowers, leading to a gradual reduction in the hermaphrodite to male flower ratio. Pollen viability also demonstrated a decreasing trend across the successive flowering months. Importantly, fruit weight and juice content were not significantly impacted by the specific period of flowering. However, a significant finding was the pronounced susceptibility of fruits developed from March flowering to cracking. This phenomenon was attributed to their developmental stage (cell expansion) coinciding with the onset of the rainy season and associated moisture fluctuations, which earlier developed fruits could not tolerate as effectively. Fruits from successive flowering periods, being in earlier developmental stages (cell division or transition), exhibited greater resilience to these environmental variations, resulting in reduced cracking.

In essence, while early flowering provided a higher initial proportion of hermaphrodite flowers, fruits from later flowering periods exhibited reduced cracking. Therefore, for farmers cultivating pomegranate in the southwestern zone of Haryana, it is advised that strategic management of the Ambe Bahar flowering period is undertaken. This involves carefully considering the trade-offs between early fruit development and the risk of cracking, aiming to optimize thinning and fruit retention practices to ensure a harvest of good quality fruits with minimized cracking.

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